

THE PRESENT STATUS AND PROSPECTS OF CHINA'S WATER RESOURCE

As an irreplaceable resource for the subsistence and development of mankind, water is a fundamental element to the continued development of economic society. To recover, save and protect the fresh water resource in a practical way is of great importance and far reaching influence on the realization of sustainable utilization of China's fresh water resource and safeguarding sustainable development of national economy.

1. Present Status

1.1 Basic data of China's fresh Water Resource

The total amount of water resource of China is 2800 billion m^3 of which surface water constitutes 2700 m^3 and ground water 830 billion m^3 , with a deduction of 730 billion m^3 for interchange and mutual makeup of surface and ground water.

The characteristics of China's water resource are described as follows:

1.2 Abundant in total amount, less in per capita occupancy

The total amount of China's water resource ranks sixth in the world, while the per capita occupancy is only 2300 m^3 which is approximately equivalent to $\frac{1}{4}$ of that of the whole world, $\frac{1}{5}$ of that of the United States and $\frac{1}{12}$ of Russia. In the three basins of the Yellow River, Huaihe and Haihe rivers in

North China, the per capita occupancy of water resource is $\frac{1}{5}$ of that of the whole country. In accordance with the statistics made by 7 organizations concerned including the United Nations Committee on Sustainable Development, the Chinese per capita average occupancy of water resource is placed 121 in the world, which tells that China is among the 13 water shortage countries of the world. See Table 2. In the light of the current international standards, in case the per capita occupancy of water resource averages 2000 m^3 the country is on the verge of serious water shortage. An average occupancy of 1000 m^3 of water resource for per capita is the minimum demand for mankind subsistence. Currently there are 16 provinces (regions, municipalities) in China where per capita average of water resource (excluding transit water) is lower than serious water shortage level, and 6 provinces and regions (Ningxia, Hebei, Shandong, Henan, Shanxi and Jiangsu) where per capita average water resource occupancy is lower than 500 m^3 (see Table 3).

The per capita average occupancy of water resource of China will be about 1755 m^3 with a further reduction by $\frac{1}{4}$ up to the middle of the next century as calculated on a population of 1.6 billion. It indicates that shortage of fresh water resource will be much severe.

Varying disposition

In China, abundant water resource are located in the South

and the East, less in the North and the West, which is **extremely unmatched to the distribution of the population, cultivated land and mineral resources etc..** The catchment areas of the Yangtze River and of the river systems to its south account for 36.5% of the total areas of China, whereas the amount of water resource within those areas account for 81% of the national total. The catchment areas of the Huaihe River and of the river systems to its north constitute 63.5% of the total area of China, but the amount of water resource in these areas merely hold 19% of the national total. The inland river catchment areas in the Northwest make up 35.3% of the total area of China, but the amount of water resource it possessed only make up 4.6% of the national total (see Table 4.). The potential value of the 49 proven mineral resources in North China area account for 41.2% of that of the national total, while water resource within this area only account for 4.7%. The mineral resources of the areas south of Yangtze River only make up 10.2 % of that of the national total, but water resource make up 42.6% of the national total (see Table5.).

☞Rain coming in step with hot weather, but varying annually and within a year

In China, precipitation varies greatly within a year because of the influence of monsoon. In most areas rainfall of four successive months in a year constitutes about 70% of the year total (approximately 60% in the South and 80% in the North).

Namely, of China's total water resource, around $\frac{2}{3}$ come from flood runoff. **Precipitation also varies greatly year by year.** In South China, the maximum annual rainfall is generally 2 ° 4 times of the minimum; and in North China 3 ° 8 times. Besides there are sometimes continuous wet years and dry years. For instance, the Songhua River had seen 11 and 13 straight years of drought from 1898 through 1908; and the Yellow River and the Yongding River had seen continuous 11 and 8 years with less water from 1922 through 1932 and from 1926 through 1933 respectively.

In general, there are abundant water resource in china and rainfall normally occurs in step with the hot season, which creates favourable conditions for subsistence and development of the Chinese nation. But the variation of precipitation distribution in time and space, because of the influence of monsoon, and the factor of the rainfall not corresponding to the distribution of population, cultivated land and mineral resources have turned China into a country of weak ecosystem and lacking of water resource and frequently suffering from floods, droughts and serious soil erosion. All these have brought about great difficulties for the development and utilization of water resource.

Present Status and Existing Problems in the Development and Utilization of Water Resource

In China, development and utilization of water resource has

a history of over 5000 years up to now. Construction of irrigation projects had constantly been taken by the past rulers of the country as fundamental important program in developing production and bringing the country into great order. Since the founding of new China and under the leadership of the Chinese Communist Party and the government, great achievements have been seen in the extensive construction of irrigation and water conservancy projects. Statistics show that, as of 1997, number of reservoirs has increased from 20 to 84,000 throughout China, with a total storage volume of over 460 billion m³. The irrigated area has increased from 16 million ha to 53 million ha. Water used for agricultural production (including irrigation, forestry, animal husbandry and vegetable production) has increased, from 100 billion m³ to 392 billion m³, by about 4 times, resulting in grain output amounting to 500 billion kilos that helped China feed its people, 22% of the world population, with its cultivated land making up 10% of the world. Industrial and urban domestic water has increased from 3 billion to 137 billion m³, an increment of 45 times, which secured swift economic and social development of China. Along with the growth of national economy, the composition of water consumption is changing. Agricultural water consumption reduced from 97% of 1949 to 70.4% of 1994, while industrial and domestic water increased from 2.9% to 24.6% and other water (including rural domestic) about 5% correspondingly.

At the moment, the actual annual water consumption of the whole nation totals about 556 billion m³ with an average of 450 m³ per capita, which is lower than the per capita average of 542 m³ of the Asian countries (see Table 6.).

Experts estimate that, restricted by natural and environmental conditions, the usable water in China amounts to 1000°1100 billion m³, accounting for 40% of the total amount of the water resource. The current actual annual consumption makes up 50°55% of the total useable amount of water. In accordance with the currently effective international standard of assessing water shortage, by the ratio of actual annual water consumption to the useable water resource as a rule, when the annual actual water consumption reaches or exceeds 40% of the useable amount of water, the nation is in extremely severe water shortage. And it is ultimately necessary to strengthen water management in supply and demand.

The key issues facing exploitation, utilization and protection of water resource are cited below:

Contradictions between supply and demand are intensifying.

First of all, **drought and water shortage are threatening agriculture.** The economic growth and climate abnormality **are intensifying the threat of drought and water shortage to agricultural production, particularly to that in North China.** In the 70s, the annual average drought stricken farmland all over

China was 11.33 million ha, and that increased to 26.67 million ha till the 90s, 2.3 times increase. In 1997, the drought stricken area of China was 33.33 million ha of which 20 million ha suffered disastrous drought and 4 million ha reaped absolutely no harvest, causing 47.6 billion kilos reduction of food grain yield. Now in China the irrigated area only is lacking of about 30 billion m³ of water every year. Drought and water shortage have become a key restriction to the stable development of agriculture and to the secured supply of grain.

Secondly, water has been in shortage in urban areas since the 70s and **become more and more grave**. Based on the statistics, of the 666 cities throughout China, more than 400 cities are in shortage of water supply with a daily shortage of 16 million m³ and an annual shortage of 6 billion m³, incurring an industrial production loss of over 200 billion Yuan per annum.

As of today, there are more than 30 million people and dozens of millions livestock suffering from water shortage over the rural areas of China. And ¹/₄ of the total population are drinking unhygienic water which has bad effect to the people's health.

~~Water~~ is wasted seriously.

The most serious waste of water is in the field of agriculture. At the moment, being the largest consumer of water, the annual water consumption for irrigation is around 392 billion m³, accounting for 70.4% of the national total. The

irrigation facilities were mostly built 30°40 years ago, some were even built hundreds of years ago. Those facilities are under standard, aged, out of repair and systematically incomplete. And with traditional earth ditches and flooding irrigation, water has been wasted considerably. About half of the irrigation water were lost through seepage in the course of flow and among the remaining half entering into the field nearly $\frac{1}{2}$ of them seeped and evaporated because of the way of flooding irrigation. Most of the utilization factors of the irrigation water are only about 0.3°0.4. That is to say, greater part of agricultural water have been wasted. The advanced western countries have adopted the way of water saving irrigation early since the 40s°50s. Now many countries have realized scientization and automation in irrigation by utilizing water-tight canals or ditches, pipelines, sprinkling and dripping irrigation and the utilization factors of the water have reached 0.7°0.8. There is much in these practical experiences that China can make use.

The risk of drying up of the Yellow River has drawn close attention of the entire society. But waste of water and pollution have not been seriously taken care of.

In the early days of new China, the irrigated area of the Yellow River was 800,000 ha with annual water consumption of 12 billion m^3 . Up to now, the irrigated area has been extended to 7.13 million ha, 6.4 times of the early days, with the water

demand for irrigation and other purpose from the Yellow River nearly amounting to the natural runoff of the river. The Yellow River is in shortage of water, meanwhile, the water was terribly wasted. The utilization factor of irrigation water is only about 0.35, and due to flooding irrigation, secondary salinization of soil has happened in some irrigated areas.

In addition, industrial water was also terribly wasted. So far, every 10,000 yuan industrial output value consumes 103 m^3 of water in China, 10°20 times of that of the developed countries (about 6 m^3 in Japan and 9 m^3 in the U.S.). The reutilization ratio of water is 40% in China whereas in the developed countries it is 75°85%. In China, producing one ton of steel consumes 20°40 m^3 of water, in the developed countries that only consumes 6 m^3 .

Urban domestic water is also in shortage, and has been seriously wasted. Based on the statistics, 15°20% have been wasted in the tap water network in most cities. The water saving, waste water recovery and utilization and rain water utilization technologies have not been properly popularized. Besides, household water has also been widely wasted. If water saving type closets and shower nozzles are adopted, household water can be saved by $\frac{1}{3}$.

Water environment is polluted.

In 1997, the total industrial and urban waste water discharge was 58.4 billion tons, of which only 23% has been treated to

the standard, and the reutilization ratio of the waste water after treatment is even lower, the rest with great part of them untreated or not been treated to the standard has been discharged to rivers or used for irrigation. Water quality assessment has been carried out on water resource throughout China. Among the 100,000 km long assessed river sections, 46.5% have been polluted, and 62.3% of the assessed length of the Haihe River have been polluted. The 1997 China Environment Bulletin reported that China's grand fresh water lakes and urban lakes were all moderately polluted. Water quality of over 50% of the monitored sections of the Yellow River, Haihe, Luanhe, Liaohe and Songhuajiang rivers are of IV grade, and the same for that of the Huaihe River except for some trunk sections of grade IV . Pollution is very grave, about 90% urban water territories have been polluted to different extents.

Undiscriminating felling of trees in the upper and middle reaches of rivers has resulted in soil erosion and reduced the ability of water conservation of the sources of water. Meanwhile, the river courses, reservoirs and lakes in the lower stream have been seriously silted up, consequently reducing the storage and regulation ability. The over exploitation of ground water has incurred surface subsidence and sea water intrusion. According to incomplete statistics, up to 56 ground water funnels have been formed throughout China, covering an area of 87,000 km². The maximum surface subsidence in the city

proper of Beijing is 0.6 m, that of Tianjin 2.6 m.

In North China, drying up of rivers is becoming more and more serious. Haihe River has become a seasonal river. Within 26 years from 1972 through 1998, drying up had happened in 20 years. It has become even more grave since the 90s. The river dried up for 122 days in 1995, 136 days in 1996, 226 days in 1997 and 142 days in 1998. In 1997, the drought stricken farmland within the basin accumulated to 4.7 million ha, causing a reduction for grain output up to 9.86 kilos. The drought and water shortage has made the Talimu River, in Xinjiang Autonomous Region, shrunk for more than 200 km, causing damage to the ecosystem.

❖The water resource is lacking rational disposition.

Abundant water resource are located in the South, and less in the North of China. But the surplus and shortage of resources are not rationally distributed. In North China, water resource have been highly exploited and water shortage has badly impacted the ecosystem. Though drying up of the Yellow River has become more and more grave, an amount of 9 billion m³ of water have been diverted from it to the Huaihe and Haihe rivers every year. It is necessary, therefore, to have a unified planning and rational distribution of the water resource of various regions, including that of the construction of water diversion projects.

❖The factor of water resource has not been adequately taken

into account when making arrangement of production forces versus development of economy.

Under the system of planned economy, less attention was paid in the past to the factors of water resource in making arrangement of industries. Not a few water consuming industries were arranged in areas where there is lacking of water. Water consuming crops such as rice were irrationally planned to grow in water shortage areas, thus further intensifying water shortage. In respect to industrial disposition, China must learn from the developed countries to place the water consuming industries in the coastal areas or along the rivers and lakes.

There is no unified control of water resource, and the price of water is on the low side.

At the moment, water resource are controlled under regional institutions and various departments, and fresh water resource are tapped and utilized free of charge. This situation is unfavourable to optimization of resources disposition and unified dispatching. **Low price is also disadvantageous to water saving** and inducing investment from various sources for tapping and utilization of fresh water resource. In accordance with statistics of 1997, in China, the current water prices are about 0.1 yuan/m³ for urban domestic (of raw water), around 0.16 yuan/m³ for industrial (of raw water), and 0.03 yuan/m³ approximately for agriculture. It can be seen that water supply

for industry, agriculture and urban/township domestic is in a state of losing money. While in European countries and in the United States, the supply prices of water are equivalent to 8 yuan/m³ (including charges for waste water treatment) and around 0.8 yuan/m³ for agriculture. Domestic and overseas experiences show that to increase supply price can help to promote water saving and to extend the service life of the facilities.

2. Prospects

The future socioeconomic growth and water resource development in China is an interactive dynamic developing process. Sustained growth of population is the fundamental condition of China. In order to realize the strategic target of reaching to the medium level of the developed countries by mid 21st century, and maintaining the economic growth rate in certain level within a long period of time, China must basically realize self-sufficiency in food grain. As the acceleration of urbanization, demand for domestic and ecosystemal water will surely increase. With a view to understand the macroscopic variation of future water demand and supply, an extra long-term forecast has been carried out.

1. Basis for the Forecast

1.1 Population

In the light of "The Agenda of 21st Century of China" the population of China will be growing to 1.3 billion by the year

2000, 1.4 billion by 2010, **1.6 billion by 2050**. At present, the population urbanization ratio in China is 28.7%, and it will be 40% by 2010, and **56% till 2050** based on experts' analysis. By then the urban/township population will be of 900 million, rural population will reach 700 million.

Food grain

While making full use of China's water and soil resources and abundant labour force, as well as domestic and overseas markets, and ensuring steady increase of food grain, it is imperative to devote major efforts to grow crops with high additional value. To feed a population of 1.6 billion, China must rely on self-sufficiency on the whole. The White Paper on food grain published by the Chinese government states that, the grain output must reach 640 million tons by 2050 calculated according to an average of 400 kilo per capita. There are 130 million ha of agricultural cultivated land over China (0.107 ha per Capita) and this figure must be kept dynamically constant with farmland maintained at 126 million ha (0.08 ha per capita) among which **irrigated areas reach to 60° 63 million ha.**

National economy

In line with the strategic goal of developing China's economy in three steps, by mid 21st century, national economy will be developed to the level of medium developed countries. The authorities concerned has forecasted that, **the**

per capita GDP will reach around 5000°7000 U.S. dollars by 2050 (equivalent to the level of present medium developed countries).

Forecast of water demand

Standard for water consumption

Estimation of agricultural water consumption mainly covers that used for irrigation of food grain fields. Currently, every cubic meter of water used for irrigation roughly produces 0.85 kilos of grain. Every 10,000 yuan production value consumes 103 m³ of water with a reutilization ratio of 40% approximately. Urban/township domestic water consumption is 220 litres/day/person and the rural domestic is 84 litres/day/person. Based on the above mentioned data, it is foreseen that by 2050, the national total water demand will reach or exceed the total amount of the national fresh water resource, which is obviously impossible.

So it is imperative, in meeting the requirement of fresh water demand and supply, to persist in water saving and recover new sources simultaneously with the former in the first place. And the amount of water consumption can only be defined according to the requirement of water saving type agriculture, industry and society. Based on the practical conditions of China and with reference to the present level of the developed countries, **the water consumption quota** for

industry of the year 2050 is defined at $7^{\circ}8\text{ m}^3$ for per 10,000 yuan production value, **reutilization ratio up to $75^{\circ}80\%$** . Taking into account the large population, water shortage and the factor that China is still in the elementary stage of socialism, the amount of township and rural water consumption can only be defined according to the low level. So the domestic water is defined at 250 liters /day per capita for township and 110 liters /day/person for the rural domestic. The utilization factor of irrigation water is set at $0.6^{\circ}0.7$, with every cubic meter of water producing 1.25 kilos of grain throughout the country.

¢Total water demand

In compliance with the aforementioned development index and the water consumption level, relevant experts estimate that, **by 2050, the total water demand will be of 800 billion m^3** , 240 billion m^3 more than the present demand. Of the total demand, **80 billion m^3 for urban domestic** which is 3 times of the present, 300 billion m^3 for industrial which is also 3 times of the present demand, 420 billion m^3 for agriculture which increases a bit than the present figure. The increased water demand for ecosystem will be met by the recovery of waste water.

££© Analysis of Supply and Demand

China's water resource are mainly located in the South where

conditions are not convenient for development and far from the demand center. To meet the demand for water in the development of social economy of the middle of the 21st century, **while practicing overall water saving and on the basis of perfecting and upgrading the existing supply facilities, a unified program of exploitation of the surface and ground water, reclamation and utilization of waste water, interbasin water diversion and utilization of sea water must be exercised** to facilitate rational development and distribution optimization as well as most effective use of water resource so as to realize a basic balance of total supply and demand of water.

At the moment, the national water supply has totaled 560 billion m³. In order to meet the above described requirement, it is **necessary to increase about 240 billion m³ of water, which can be realized through the following measures:**

④ Reinforcing, perfecting and upgrading the existing reservoirs and irrigation facilities

Currently the total storage volume of the reservoirs all over China is 480 billion m³ with a profitable volume up to 250 billion m³. Due to aging, lacking of repair and system incompleteness, $\frac{1}{3}$ of the reservoirs are defective and dangerous. Actually there are only 160 billion m³ of water can be supplied annually, and about 90 billion m³ profitable storage have not been fully utilized for regulation and storage. Besides, it is possible to increase the regulation and storage

capacity of some of the reservoirs if the flood forecast and dispatching are more precise. Among the irrigation facilities of China, 60°70% of them are built not to the design standard and the resources have not been fully used. **It is anticipated that about 50 billion m³ of supply capacity can be increased by reinforcing, perfecting and upgrading the existing reservoirs and irrigation facilities.** As comparing with building new projects, it has the advantages of less investment, quick effects, higher profits, no inundation and resettlement. It is a measure deserved to be put on the first priority.

¢To build a group of new projects in a planned way

First of all, it is important to **rationally develop local ground water resource.** The exploitable ground water resource of China is of 290 billion m³. Up to now, 100 billion m³ have been tapped, accounting for 1/3 of the total. There are potentials remaining to be developed. By adopting a principle of “digging wells in places where there is water sources, integrating wells and canals, saving water in irrigation and practicing strict management”, it is possible to **further exploit 25 billion m³ of water** from the catchment areas of Songhuajiang-Liaohe rivers, Xinjiang and Ningxia and Inner Mongolia Autonomous Regions, Huaihe basin and areas of the lower reaches of the Yellow River.

Secondly, in dry and mountainous areas, it is necessary **to**

widely mobilize the masses to build small and micro water conservancy and rain water collection projects which can help to increase a storage volume of 5 billion m³.

Thirdly, **construction of water storage projects must be speeded up.** To date, **the profitable volume of the reservoirs under construction accounts for 200 billion m³ and that of planned and proposed reservoirs will constitute 50 billion m³, which can increase a supply capacity by 50 billion m³.**

The fourth measure is to build a group of water diversion and pumping projects. The nationwide water diversion and pumping projects currently in progress or planning have a **potential capacity of increasing supply up to 30 billion m³ annually.**

The fifth measure is **to build trans-basin water diversion projects**, including diverting water from the South to the North, diverting the north water from Xingjiang and the Northeast to southern areas, diverting water from the Yangtze River to the Huaihe River, dredging the Grand Canal and diverting water from the west to the east in Liaoning province etc., **by which an amount of 40°50 billion m³ of water can be diverted.**

¢To turn the waste water as sources of water and to make use of the sea water

Based on the above demand forecast, by 2050, urban

domestic water consumption will amount to 80 billion m^3 annually, with waste water treatment ratio up to 70% and **waste water reutilization amounting to 20°25 billion m^3** . There will be 160 million m^3 of industrial and the rest domestic waste water that, after treatment, can be used for environmental purposes.

In coastal areas, sea water can be used instead of part of the fresh water as industrial cooling and non-drinking purposes. There is a long way to go in China in utilization of sea water as compared with the advanced countries of the world. Direct utilization of sea water in China is around 8.5 billion annually, while in Japan it is 120 billion m^3 and in the United States about $\frac{1}{3}$ of the industrial water comes directly from the sea. There are proven experiences in substituting sea water for fresh water in the coastal regions in China, which deserved to be collected and popularized. It is estimated that, up to 2050, direct use of sea water will increase to 50°80 billion m^3 , equivalent to 5°8 billion m^3 of fresh water.

Through the aforementioned measurements, **by 2050, the supply capacity of China can be increased by 240 billion m^3 approximately. The total annual supply capacity of the fresh water resource will roughly reach to 800 billion m^3** throughout China which can basically meet the fresh water demand in the development of social economy. In the later

50 years of the present century, with “recovering resources” as a key principle, China has increased a fresh water supply of over 400 billion m³ which on the whole satisfied the demand of socioeconomic development. Within the first 50 years of the next century, China will adhere to the principle of “practicing all-round water saving, well protection and positive recovery of resources” so as to further increase fresh water supply by 240 billion m³, thus realizing a sustainable development of economic society.

3. Policies

(1) Taking water saving and resources protection as a basic policy of China

To feed a population of 1.6 billion, one of the key issues is water. The effective supply of water is a key factor related to the development of industry and urban/township economy. Along side the growth of population and national economy, **water environment and pollution in particular have become a more and more outstanding problem. Protection of limited water resource are of great importance. China must take water saving and recovering resources as a basic policy in water resource development and utilization.**

(2) Adhering to saving, recovering and protecting the resources with saving in the first place.

- ✳ The future agricultural water demand will mainly depend on the water to be saved. Water saving irrigation will not only be a way of saving water but also an important measure of agricultural modernization. Water saving irrigation must be popularized as exercising a revolutionary measure.
- ✳ The future industrial and urban domestic water will constitute a greater part of the future demand and major sources of pollution. To save water will not only reduce water consumption and also reduce waste water discharge. To save water means to reduce pollution. Water saving must be extensively exercised in industrial production and in cities/towns and reutilization ratio of water must be greatly enhanced.
- ✳ A tariff system must be established in line with the laws of market economy so as to encourage water saving.
- ✳ Construction of water saving and waste water recovery projects must be put on an equally important position in the capital construction program as that of new projects.

(3) To work out a sound general program of development and utilization so as to optimize distribution of water resource.

- ✳ A general program for development, utilization and protection of water resource must be prepared with a

view to sustainable tapping of water resource and in tune with the growth of population, economy and environment.

- ✳️ A rational distribution of water resource between catchment areas of the Yangtze, Huaihe, the Yellow and the Haihe rivers must be planned as a whole to solve water shortage of the North China and the drying up of the Yellow River.
- ✳️ The adjustment of economic structure and arrangement of production force must take full account of water resource condition. The coastal areas must make full use of sea water in the socioeconomic development.
- ✳️ Water diversion from other basins shall be carried out on the basis of rational utilization of local water resource, applying water saving and reusing waste water after treatment.

(4) To put stress on the set up of water saving, recovering and protection works in the coming capital construction

- ✳️ From now till 2015, the population and economy and the demand for water will grow in a faster pace. Emphasis must be placed on and input must be increased for saving, recovering and protecting of water resource in infrastructure construction, .
- ✳️ With a main purpose of saving water, the large size irrigation facilities must be upgraded as construction of

key infrastructure project.

- ✱The issue of meeting serious water shortage of some areas of China must be put on the agenda as soon as possible. The scheme of diverting water from the South to the North, to solve the problem of North China water shortage and drying up of the Yellow River, must be figured out on the basis of elaborated considerations, comparison and well-conceived planning.

(5) To perfect water laws and enforce unified management of water resource

- ✱To perfect water laws to bring the water resource under effective control.
- ✱To enforce unified control of water resource and set up unit management system on the basis of each river basin.
- ✱To tighten unified management of surface and ground water resource with particular attention to practicing planned and rational management and realizing sustainable utilization of ground water resource.